

## PATIENT MONITORING SYSTEM

### RELATED CASES

This application is a continuation-in-part application of United States application 09/151,020 filed September 10, 1998, by inventor, Kristin Robert Stroda, for the invention entitled PATIENT MONITORING SYSTEM.

### BACKGROUND OF THE INVENTION

This invention relates to patient monitoring systems in which the movement or location of a patient is determined by one or more sensors at least one of which is a pressure sensitive sensor.

In some systems of this type, the movement or location of a patient is determined by any of a plurality of redundant or cooperating sensors. When one or more of the sensors indicates the existence of a problem concerning the patient, the patient monitoring system provides an alarm or a warning. In other systems, a single sensor detects an unauthorized location, movement or position of the patient and provides an alarm.

In one class of these patient monitoring systems, a sensor indicates the departure of a patient from his or her expected position and the system responds by providing an alarm. In one such system, a cord or other fixed length member has a fastener on one end and an activator on the other end and the activator is connected to a monitoring housing so that if the fastener moves beyond the fixed length, the monitoring housing is activated.

The fastener is connected to a patient such as to the clothing of a patient by a clip so that, if the patient moves beyond the fixed distance such as by slumping from a wheelchair onto the floor or moving from a bed, the monitoring housing provides an alarm.

In a prior art monitoring system of this type, the end of the cord having the activator opposite to the fastener is loosely fitted into the monitoring housing so that when the patient moves away from the monitoring housing a distance greater than the length of the cord, the activator is pulled free. When the activator is pulled free from the monitoring housing, an alarm is given. Prior art systems of this type are disclosed in United States Patents 4,577,185, 4,858,622, and 4,583,084 and systems of this type are on sale under the trademark, TABS, by Wanderguard, Inc., a division of Senior Technologies, Inc., located at 1620 North 20<sup>th</sup> Street, P.O. Box 80238, Lincoln, Nebraska 68503.

This type of prior art patient monitoring system has several disadvantages, such as for example: (1) from time to time the fastener falls loose from the patient or is removed by the patient so that the system fails; (2) the patient may become entangled in bedding or the like or fall from the bed or chair or partly fall at a distance that does not pull the cord free; and (3) the cord may break or be cut.

In another class of patient monitoring systems, the patient in a bed or a wheelchair rests on or near a pressure pad. Changes in pressure on that pad cause a signal indicating that the patient is moving in a manner that indicates some type of problem. In a prior art monitoring system of this type, a manual switch is activated by an attendant or patient when the patient is in place to initiate the monitoring system and inactivated when the patient leaves in an ordinary non-troublesome manner. One such prior art system is

disclosed in United States Patent 4,907,845.

This type of prior art monitoring system has several disadvantages such as for example: (1) the switch may be accidentally thrown or thrown by a patient intending to move but for whom it is undesirable to move unattended because of confusion of the patient or illness to the extent that the patient does not appreciate; (2) because the pressure pad is positioned in the bed beneath the patient, it flexes as the patient moves, causing the cord to flex, eventually fail and thus prevent the signal being given if the patient leaves; (3) the pad may be defeated by folding or placing a weight on it; and (4) some of the pressure pads are expensive to purchase and maintain.

Some prior art pressure pads are relatively expensive. In the prior art the pressure pads are intended to be used for an extended period of time and may be used in connection with several patients. This type of pressure pad and method of use has several disadvantages such as: (1) it is subject to cross contamination in some cases, or in the alternative, requires relatively expensive pads to be discarded and new pads used when the patient is discharged from the facility; (2) the battery becomes faulty if it is battery operated; and (3) the battery must be checked and replaced to avoid an accidentally inoperative system from being used.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a novel patient monitoring system.

It is a still further object of the invention to provide a novel pressure pad sensor that

can be used in conjunction with other sensors to monitor a patient.

It is a still further object of the invention to provide a novel disposable pressure sensor for monitoring patients.

In accordance with the above and further objects of the invention, a novel patient monitoring system is provided with one or more sensing modalities that alone or in cooperation with each other offer greater reliability. A novel disposable sensor is also provided that may be used in the novel patient monitoring system or alone. In this system of monitoring patients, an alarm or instructions to the patient are given when the patient assumes a dangerous position. The alarm signal is provided to the caretaker such as at a nurses station and a voice message is announced in the vicinity of the patient, when the patient assumes the dangerous position. The sensor may be armed by the application of weight to it and a signal may be provided to a caretaker, when the weight is removed or another sensor detects an alarm condition such as motion beyond a predetermined distance.

The patient monitoring system of this invention has several advantages, such as for example: (1) it provides redundancy so that if one alarm fails the other may succeed to provide a warning alarm; (2) it permits the selection of one or more sensing conditions and combinations of different types of sensors such as one that locates the distance that the patient has moved and another that indicates that the patient has lifted himself or herself off of a pressure pad or has swung his or her legs over the edge of a bed or applied a substantial amount of his or her weight to a support for lifting his or herself from a bed or wheelchair; (3) it can detect distress conditions that might otherwise be missed such as

for example a cord indicating a patient is leaving the bed or wheelchair or has fallen from it and a release-of-pressure sensor that indicates the patient may be thrashing about within the length of the cord or dangling from the bed or chair without exceeding the length of the cord; (4) it is difficult for the patient to defeat; (5) it is relatively flexible in the condition or conditions to be sensed and the nature of the alarm or alarms, or the warnings or messages to the patient, or the sequence of the alarms and messages and the location or locations of the alarm with respect to the caretaker of the patient; and (6) an inexpensive disposable pressure pad may be used to permit disposal after each patient and the use of a new pressure pad.

#### SUMMARY OF THE DRAWINGS

The above noted and other features of the invention will be better understood from the following detailed description when considered in connection with the accompanying drawings, in which:

FIG. 1 is a simplified perspective view of an embodiment of the invention;

FIG. 2 is a block diagram of a patient monitoring system in accordance with the invention;

FIG. 3 is a fragmentary, simplified perspective view showing a manner in which the fastener, a cord and pressure pad are used to monitor a patient;

FIG. 4 is a fragmentary simplified perspective view illustrating the use of the patient monitoring system in connection with a wheelchair;

FIG. 5 is a simplified, perspective, fragmentary view illustrating the use of the

patient monitoring system in connection with a bed;

FIG. 6 is a simplified partly perspective and partly schematic view of a portion of the embodiment of FIG. 1;

FIG. 7 is a block diagram of the control system for an embodiment of the invention;

FIG. 8 is a flow diagram of the program for determining an alarm condition using a pressure pad;

FIG. 9 is a schematic block diagram of a threshold circuit for the pressure pad;

FIG. 10 is a fragmentary perspective of a disposable pressure pad positioned on a bed to monitor patients in accordance with an embodiment of the invention;

FIG. 11 a fragmentary perspective view of a disposable pressure pad in accordance with an embodiment of the invention;

FIG. 12 is a schematic circuit diagram of a control unit used in an embodiment of pressure pad;

FIG. 13 is a fragmentary perspective view of a portion of the pressure pad of FIG. 11;

FIG. 14 is an exploded perspective view of another embodiment of a pressure pad; and

FIG. 15 is a perspective view of the embodiment of FIG. 14.

## DETAILED DESCRIPTION

In FIG. 1, there is shown a simplified perspective view of a patient monitoring system 10 having a wheelchair pressure pad switch 11A a bed pressure pad switch 11B,

a cord 60 and a housing 13. A microprocessor (not show in FIG. 1) within the housing 13 is electrically connected to either one of the wheelchair or bed pad pressure switches 11A and 11B (first sensor) to cooperate with them and receive a signal when pressure is applied to the pads or released from the pads. The cord switch 34 (second sensor) includes a clip such as a badge or alligator clip 12, a cord 60 and a magnetic shunt 63 adapted to fit into a slot 67 in the housing 13. The clip such as a badge or alligator clip 12 is on one end of the cord 60 and the shunt 63 on the other.

The alligator clip or other connector 12 is fastened to the clothing of the patient and the disk 63 put into the slot 67. When it is removed such as by the person moving a distance greater than the length of the cord 60, an alarm and/or voice is sounded. Similarly, when pressure is placed on either the pad 11A in a wheelchair embodiment or the pad 11B in a bed near the shoulders of a patient, a flag on the microprocessor is set so that when the patient releases the pressure such as by getting up from the seat of the wheelchair or sitting up if on a bed, the microprocessor receives a signal resulting in an alarm or voice message and alarm.

To establish the electrical connections between the pressure pads and microprocessor or to pulse forming equipment or threshold equipment for processing signals for input to the microprocessor within the housing 13, the pressure pad 11A is connected by an electrical conductor 65A to the conductor 30 and the bed pressure pad switch 11B is connected by a conductor 65B to conductor 30 with the conductor 65A being shown connected to the conductor in FIG. 1. The input circuits for the microprocessor may be incorporated within the housing 13 and its role is to develop a signal for the

microprocessor when pressure is applied on the pressure pads 11A and 11B, which in the preferred embodiment is a pad that reduces resistance when pressure is placed upon it. Other types of pressure pads are known in the art and any of them may be used but some of them would not require the input circuit 15 but would generate their own signal.

In the preferred embodiment, the pressure pads are described in United States Patent 5,796,059 to Stephen Boon which are manufactured and available from Senior Technologies, Inc., 1620 North 20<sup>th</sup> Street, Lincoln, Nebraska 68503, but other types are known such as those disclosed by United States Patents 4,263,586 and 4,020,482. The pressure pad described in the aforementioned United States Patent 5,796,059 is able to provide signals indicating the location on the pad of pressure and thus, with the aid of the microprocessor detect and indicate shifts in position of the patient such as tilting in a wheelchair or moving to the edge of a bed. While in the preferred embodiment the pressure pad is placed under the bedding it can be placed at other locations such as under the mattress. Moreover, it may be used with an analyzer such as a microprocessor to detect direction of movement such as whether a patient is moving toward a door or away from a door by detecting directional changes in pressure.

In this specification, a sensor includes any device which senses a position or motion or location of the patient. The term sensor not only includes the device for sensing the position, location, movement or the like of the patient but any error correcting or redundant part of it which indicates a failure condition of the sensor itself.

For example, in United States Patent 5,494,046, a clip such as a badge or alligator clip is disclosed attached to a cord and a magnetic shunt similar to that of the preferred

embodiment of this invention. However, the clip such as a badge or alligator clip is designed so that while it is fastened to the garment of the patient, it in itself has an open circuit but when removed, it has a closed circuit so that if this particular sensor has been removed from the patient and is thus disabled to not detect if the patient moves beyond the length of the cord from the housing 13, a signal nonetheless will be provided. However, in this specification it is considered one sensor because it indicates the length of the patient from the housing 13 or the failure of the sensor to be able to detect such a position of the patient.

In FIG. 2, there is shown a block diagram of a patient monitoring system 10 having a first sensor 32, a second sensor 34, the patient-station monitoring housing 13, a station alarm system 14, a station control and interface system 15, and a remote station alarm 20. The patient-station monitoring housing 13 may include a voice record system in the manner disclosed in United States Patent 5,494,046 for providing verbal instructions to a patient under certain sensed conditions. As in the case of the system described in United States Patent 5,494,046, the disclosure of which is incorporated herein for reference, an alarm is given at the station with the patient and/or a nurses station before a voice carries a message to the patient so that immediately upon the sensing of an alarm condition, the attendants receive notification and can proceed to the aid of the patient.

In the preferred embodiment, the second sensor 34 is a clip such as a badge or alligator clip attached to a cord which moves an object in juxtaposition with the housing 13 such as a magnetic shunt that can be removed or a magnet that activates a reed switch, either placed inside or outside of the station alarm unit 14 and the housing 13 or any other

type of sensor, many of which are described in United States Patent 4,494,046 such as photocell sensors that senses the removal of an object from the housing 13 by uncovering a light path or a mechanical device or any of many sensing devices such that may sense the removal of an object from the interior of the housing 13 or the surface of the housing 13. Because the other sensor develops signals with a different criteria it may be used to reset the pad. For example, the pad sensor may be reset by removing and reinserting the plug 63 into the opening 67 rather than using pressure to both reset after a signal and to arm the sensor.

The station alarm 14 may include a lamp or a buzzer or the like and the remote station 20 may be connected by wires 26 to receive an alarm such as at a remote location such as a nursing station or may have an antenna 24 which receives a signal from the station alarm or transmits a signal to other stations so as to provide an alarm at those stations. The alarms at the remote stations may also be any type of indicator such as a lamp, a buzzing sound, a ringing sound, a horn-like sound, or a voice.

While in the embodiment of FIG. 2, alarms are provided before the message is played both near the patient and at a remote location, the alarm nearby from the station alarm may be omitted and the signal transmitted directly to the remote station or alarm 20 or the message may be played simultaneously with either or both the station alarm 14 and remote alarm 20 or before either or both alarms. The voice system may be any standard commercial arrangement such as are now commonly used to play a fixed message. In the preferred embodiment, the voice system is a single chip, voice record/playback device Model ISD14XX sold under the trademark DAST by Information Storage Devices, Inc.,

2841 Junction Avenue, Suite 204, San Jose, California 95134.

In FIG. 3, there is shown a fragmentary, simplified perspective view of a patient 64 wearing a garment 62 and having an alligator clip or other fastener 12 fastened to the garment 62 and connected by at least one length of cord 60 to the housing 13 at the patient station constituting the second sensor which is a cord switch 34 in the embodiment of FIG. 1 and a pressure pad 11A and switch 15 constituting a first sensor 32. In the preferred embodiment, the clip such as a badge or alligator clip 12 is fastened by a first length of cord 60 to a switch member (not shown in FIG. 3) that may be pulled from its position in the housing 13 to signal an alarm easier than the alligator clip or other fastener 12 is freed from the garment 62. The pressure pad 11A is intended to be on the seat of a wheelchair to provide a signal if the patient leaves the wheelchair.

The length of cord 60 should be selected for the use but should be within a range of five inches to five feet and preferably within a range of ten inches to twenty-four inches for a chair and still more preferably fifteen or eighteen inches for a chair. It should be preferably within a range of two feet to three feet for a bed and still more preferably thirty inches.

The alarm switch may be of any type, such as for example the switch disclosed in U.S. Patent 4,160,972, the disclosure of which is incorporated herein by reference when used to activate an alarm when the switch is opened. To activate an alarm when a switch is closed rather than when opened, a source of power in series with the alarm and switch may be used. Moreover, a voice processor 90 (FIG. 7) within the housing 13 may be used with other types of systems such as that disclosed in U.S. Patent 4,577,185, the disclosure

of which is incorporated by reference herein, to provide an alarm when the length of cord 60 is pulled free from the housing. Thus, the cord 60 may pull a ferromagnetic member away from a reed switch or may pull a mechanical switch closed or open or may move an opaque object from or into a location between a light source and a photocell to change the state of a switch and thus activate a voice recording and one or more alarms. The alarms 14 and 20 (FIG. 2) may be audible or visual or both.

With this arrangement, if the patient were to move further away from the housing 13 such as by falling from a chair or leaving a bed, the cord 60 would stretch and pull the magnetic shunt 63 (FIG. 1) or other member, free from the slot 67 (FIG. 1), closing a circuit in the housing 13 to activate the alarm and/or voice recording. Moreover, if pressure were released on the pads 11A or 11B a signal would be given to provide an alarm.

The alligator clip or other fastener 12 is generally fastened to the torso of a patient such as on a shirt or the top part of a hospital gown or the like in the vicinity of the shoulder and the cord 60 is sized in accordance with the location of the monitoring apparatus. For example, in a wheelchair, the cord 60 is generally 18 inches long and in a bed setting it is generally two feet long. It should be no shorter than one foot and no longer than five feet in length. The housing 13 is generally fastened to a nearby support.

In FIG. 4, there is shown a fragmentary, simplified perspective view of a wheelchair 66 showing an appropriate mounting for the housing 13 above the wheelchair with the cord 60 preferably facing upwardly and being connected to the clip such as a badge or alligator clip and magnetic disk 63 in the slot 67 of the housing 13 so that a patient in the wheelchair may have the clip 12 fastened to the patient's garment. The pressure pad 11A

is under the patient's seat so that the patient's weight is upon it. In the preferred embodiment, the cord is fifteen or eighteen inches long. If the patient then slumps forward out of the chair, the disk 63 is pulled free from the slot 67 or pressure released on the pressure pad 11A, the housing 13 provides an alarm signal to a caretaker, preferably at a remote location. The recorded message in an embodiment of this type may request the patient to remain stationary until aid arrives.

In FIG. 5, there is shown a simplified, perspective, fragmentary view of a bed 68 equipped with a patient's station monitoring housing 13 mounted to the headboard so that a clip such as a badge or alligator clip 12 (FIGS. 1 and 3) can be fastened to a patient. The cord 60 has a sufficient length so that if the patient falls from the bed or attempts to leave, the cord 60 will cause either the disk 63 (FIGS. 1 and 4) to be pulled from the housing 13 or the pressure pad 11B to receive less weight and generate a signal. The pressure pad is preferably under buttocks but may be anywhere else that will generate weight related signals such as under the shoulders of the patient. In either case, a message may be played requesting the patient to remain in the bed or instructions may be given to the patient and/or an alarm may be transmitted to a caretaker who can attend to the matter. In the preferred embodiment, the cord is two feet long.

In FIG. 6, there is shown a simplified, fragmentary, partly-perspective and partly-schematic view of one embodiment of the patient monitoring system 10 having the first length of the cord 60, the station alarm 14, the pressure pad sensor conductor 30 connected so that when the magnetic shunt 63 is pulled free from the housing 13, the reed switch 73 closes about the power supply 69 to send a signal through the conductor 61 to

the station control and interface system 15 to provide an alarm signal and when the weight on one of the pressure pads is released, a signal is sent through conductor 30 through the station control and interface system 15 to provide an alarm. The station control and interface system 15 performs the "OR" function within the microprocessor 94 (FIG. 7) or by a separate "OR" gate before the microprocessor.

In the embodiment of FIG. 6, the housing includes a permanent magnet or an energized electromagnet 71, a reed switch 73, and ferromagnetic path members 75, 77 and 79. The ferromagnetic path members 75, 77 and 79 form a closed ferromagnetic circuit with the magnet 71 to close the reed switch and prevent an alarm. This ferromagnetic circuit maintains the normally open reed switch 73 in its closed position. When a ferromagnetic shunt 63 is removed and the reed switch opens an alarm is given. Of course, a normally closed switch can be used by reversing other circuit elements and other sensors can be used. With this arrangement, when the disk 63 is pulled free, a signal is transmitted to the station control and interface system 15 and the station alarm 14 to initiate the voice message and/or alarm from the voice processor 90 (FIG. 7) of the housing 13 (FIGS. 1, 3, 4 and 5) and the remote station alarm 20 (FIG. 2) as explained in connection with FIG. 2.

FIG. 7 is a block diagram of the control system for an embodiment of the invention and has its principle parts a microprocessor 94, a transmitter 98, an alarm speaker 112, a nurse call 96 and a voice microprocessor 90. The microprocessor 94 is a type PIC16C54 Microcontroller sold by Microchip Technology, Inc. of Arizona. It's an 18-pin microprocessor having an input 102 for tone select, an input 104 for another tone select,

an input 106 for local alert and 108 for local voice to set the microprocessor 94.

With this arrangement, when an input signal is received from the conductor 30, a flag is set in the microprocessor 94. When a signal is received indicating a release of the pressure, the microprocessor 94 transmits an alarm signal to the nurse call station 96, the transmitter 98 and the alarm speaker 112 within two and one-half seconds unless the pressure is again applied to the sensing pad. If set for that purpose, a signal may be sent to the voice microprocessor 90. This provides the warning to the patient. Similarly, a signal from the station control and interface system 15 (FIG. 6) or similar component in other circuit arrangement from other sensors indicating that the first sensor which is the magnetic shunt 63 has been pulled free, initiates an alarm signal.

In FIG. 8, there is shown a flow diagram of a program utilizable in the microprocessor 94 (FIG. 7) to determine an alarm condition using a pressure pad which program includes a start step 120, a wake-up or power starting and initializing step 122, an alarm condition detecting step 124, a timer step 126 and a go to start step 128. With this arrangement, the microprocessor 94 (FIG. 7) is initialized such as at the step 122 and determines if there is an alarm condition caused by the shunt being removed or the pressure pad being armed and removed, determines if there is an alarm condition on the pad if it lasts for approximately 2.5 seconds and returns to start step 128.

The alarm condition detecting step 124 includes the steps of determining if the shunt is pulled at step 130, providing an alarm signal as shown at 132 if it has been pulled, and if it has not been pulled, going to the decision step 134. The decision step 134 determines if the pad is present and if it is, the program proceeds to the arm the pad step

136 by applying a pressure pad flag if pressure has been applied to the pressure pad to reduce resistance. If the pad is not present, then the program proceeds to the decision step 138 to determine if there is an armed pad flag, and if there is, then it proceeds to the step 140 to provide an alarm. If not, it proceeds to the timer step 126 and from there back to the start step 120 from the go to start step 128. If the armed pad flag 136 is set as a result of the pad being present and weight being upon it then the program proceeds to the timer step 126 and from there back through steps 120, 122, 130, 134, 138 and alarm step 140. With this arrangement, an alarm is provided if the shunt is pulled or if the flag is armed and weight is removed for approximately 2.5 seconds.

In FIG. 9, there is shown a schematic block diagram of the microprocessor circuitry 94 connected to the pad 11A. The pad is energized by a source of voltage 150 and applied to the pad 11A through a resistor 152. A comparator 154 has its noninverting input terminal energized by the battery source 150 through an adjustable resistor 156 that determines a threshold value for the pad that can be set to accommodate the weight and size of a person on the pad. The pad provides the signal as determined by 150 and controlled by the resistance of the pad 11A to the inverting terminal of the comparator 154 to initiate a timer 158, which may be within the microprocessor or separate from the microprocessor. If this condition as determined by the comparator 154 lasts for approximately 2.5 seconds then the microprocessor provides an alarm signal. But if the threshold from the pad 11A as applied to the comparator 154 falls at the noninverting input terminal, then the timer 158 is reset and no alarm is given.

In FIG. 10, there is shown another embodiment 160 of a pressure sensing pad

resting on a bed 162 having a control unit 164, a pressure sensor 166 and an enclosing case 168 (168 not being numbered in FIG. 10). The case 168 is made of a flexible or partly flexible material that feels good to the touch such as plastic or partly plastic and partly cloth or any other materials. The control unit 164 is located in a pocket within the case 168 so that a control surface is exposed and available for setting. Otherwise, the case 168 entirely encompasses the pressure sensor 166 and seals the pressure sensor against most moisture. The pressure sensing pad 160 is intended to be disposable so that it may be used with one patient and then disposed of.

In FIG. 11, there is shown a fragmentary perspective view of one embodiment of the disposable pressure sensing pad 160 showing the enclosing case 168, the control unit 164 and a pressure sensor 166. In this embodiment, the pressure sensor 166 is a gel pad of the type used for patients having sensitive areas to rest upon, with one or more tubes 165 communicating with the interior of the gel pad or pads 166 and with the pressure switch in the control unit. The plastic casing 168 is sealed around the control unit 164 leaving a control face 170 exposed to permit adjustment of the amount of pressure necessary to cause an alarm to be given by the pressure sensing pad 160. The pressure sensor 166 may remain enclosed and the amount of pressure that must be applied to it to activate it may be set by a bias adjustment manual dial 190 (190 not being numbered in FIG. 11). In other embodiments, the pressure may be preset at the factory and the pressure sensing pad sold calibrated to a certain pressure. If multiple gel pads are combined into one pressure sensing pad, then multiple tubes 165 must connect to a manifold and the manifold to the pressure switch in the control unit 164.

In FIG. 12, there is shown a schematic circuit diagram of the control unit 164 having a double-pole, single-throw pressure-activated switch 172, a time delay circuit 180, an audible alarm 186, an on/off switch 182, a battery 184, and a lamp 188. The double-pole, single-throw pressure-activated switch 172 has a first switch contact set 176 and second switch contact set 178 and an actuator plunger 174. The actuator plunger 174 communicates with a pressure sensor so as to be held open when pressure beyond a preset value is placed on the pressure sensor that is beyond a preset value of pressure. This switch 172 also opens a switch contact set 178 in circuit with the time delay circuit 180 and the switch contact set 176. This switch arrangement is in circuit with the audible alarm 186, the lamp 188, a single-pole double throw on/off switch 182, and the battery 184 so that when the switch 172 is closed, the normally open switch contact sets 176 and 178 are opened by pressure to open the circuit that includes the battery 184, the audible alarm 186 and the lamp 188. The on/off switch 182 is a third switch that may open the circuit.

When the on/off switch 182 is closed and there is no pressure upon the pressure sensor, the circuit is completed through the normally open switch contact sets 176 and 178, the time delay circuit 180, the alarm 186, the lamp 188, the on/off switch 182 and the battery 184 so that the lamp 188 is illuminated and the alarm 186 given. When pressure is applied to the pressure sensor beyond a preset amount as set by the bias adjustment manual dial 190, the circuit is broken, or if the circuit is turned off by the on/off switch 182, the circuit is broken. If the on/off switch 182 is closed and pressure is removed from the double-pole, single-throw pressure-activated switch 172, a signal is sent through the time delay 180. If the switch 172 remains inactivated, the signal passes through the switch

contact set 178 and the alarm 186 sounds and the lamp 188 is illuminated. However, if while the circuit signal is passing through the time delay circuit 180, pressure is again applied to the pressure sensor, then the switch contact set 178 is open and no alarm is given. With this arrangement, if the pressure sensing pad 160 is placed on a wheelchair or a bed and energized by closing the on/off switch 182, the pressure will open the switch contact sets 176 and 178 so there will be no alarm. However, if the patient leaves the seat or the bed, the normally open switch contact sets 176 and 178 will close and if they remain closed after the time of the time delay circuit 180, the alarm 186 will sound and the lamp 188 will be illuminated unless the on/off switch 182 is open. The switch 172 includes an actuator plunger 174 which may be in physical contact with the interior of the pad and which is adjustable by the bias adjustment manual dial 190. This sensor may be similar to the sensor in United States Patent 4,336,533.

In FIG. 13, there is shown a fragmentary perspective view of the control unit 164 within the case 168, with the case 168 sealed to the control face 170 leaving exposed the lamp 188, the speaker of the alarm 186, the bias adjustment manual dial 190 and the on-off switch 182. With this arrangement, the activating pressure may be set to accommodate different weight patients by the bias adjustment manual dial 190. The on-off switch 182 is accessible to control the pressure sensing pad 160, and the lamp 188 (FIG. 12) and alarm 186 are easily seen and heard.

When a preset time period is near its end or a patient is discharged and it's desirable to dispose of the pressure pad and provide a new one for a new patient, the plastic casing may be torn to indicate that the disposable pad is to be discarded and may

be discarded in whatever provision is made within the nursing home or hospital for discarding such used disposable items. Thus when a new patient is admitted, a new pad may be used with the patient and assigned to the patient so that there will be no cross contamination between patients. The pads have a preset life and if that life is exceeded, then the pad is changed and a new pad is assigned to that patient. When the patient is discharged, the pad is discarded.

While a gel pad of the type sold by Deka Medical, Inc. P.O. Box 2426, Columbus, MS 39704 under the trademark Gel-Lite is desirable, combined with the pressure switch such as that disclosed in United States Patent 4,336,533, other types of pressure sensitive pads and switch mechanisms may be used. For example, the switch mechanism described above may be used and this pad may be incorporated as part of the multiple sensor configuration described in this application. Similarly, other pads may be utilized although because the pad is disposable, it is desirable that inexpensive types of sensing pads be used.

In FIG. 14, there is shown an embodiment of a disposable pressure sensing pad 160A having a commercial gel pad 202, a vinyl cover shown at 204A and 204B and a sensor 165A. The sensor 165A may be of the type disclosed in United States Patent 5,990,799 issued November 23, 1999, to Boon et al having a pressure activating switch 172A, an electrical cord 206 and a control unit 164A containing an alarm and jack socket 208 for receiving a nurse call of the type sold by Senior Technologies, Inc., 1620 North 20<sup>th</sup> Street, Lincoln, Nebraska 68503, under the trademark, Arial nurse call.

In FIG. 15, there is shown a perspective view of a disposable pressure sensing pad

160A completely assembled to be entirely covered by a vinyl cover 204A and 204B and having the cord 206 extending from it. The vinyl cover 204A and 204B may be a continuous vinyl pouch integrally formed to be sealed at one end or may be in sections sealed after the sensing pad has been positioned in place. The control unit 164A has a face 170A to indicate the condition of the battery, an alarm and a jack socket 208 for receiving a nurse call unit 96A containing a jack 212 to be inserted in the jack socket 208. With this arrangement the pad 160A may be discarded after a patient is discharged or if it becomes soiled, saving the nurse call unit 96A and in some embodiments the control unit 164A which may be connected to the cord 206 by means of a jack socket 208.

The patient monitoring system of this invention has several advantages, such as for example: (1) it provides redundancy so that if one alarm fails the other may succeed to provide a warning alarm; (2) it permits the selection of one or more sensing conditions and combinations of different types of sensors such as one that locates the distance that the patient has moved and another that indicates that the patient has lifted himself or herself off of a pressure pad or has swung his or her legs over the edge of a bed or has applied a substantial amount of his or her weight to a support for lifting his or herself from a bed or wheelchair; (3) it can detect distress conditions that might otherwise be missed such as for example a cord indicating a patient is leaving the bed or wheelchair or has fallen from it and a release-of-pressure sensor that indicates the patient may be thrashing about within the length of the cord or dangling from the bed or chair without exceeding the length of the cord; (4) it is difficult for the patient to defeat; (5) it is relatively flexible in the conditions to be sensed, the nature of the alarm or alarms or the warnings or messages

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